ADA

INLINE MONITORING OF FREE WATER AND PARTICULATE CONTAMINATION OF JET A FUEL

INTERIM REPORT
TFLRF No. 466

by
Keri M. Petersen

U.S. Army TARDEC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

for
Joel A. Schmitigal
U.S. Army TARDEC
Force Projection Technologies
Warren, Michigan

Contract No. W56HZV-09-C-0100 (WD27)

April 2015

Disclaimers

Reference herein to any specific commercial company, product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the Department of the Army (DoA). The opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or the DoA, and shall not be used for advertising or product endorsement purposes.

Contracted Author

As the author(s) is(are) not a Government employee(s), this document was only reviewed for export controls, and improper Army association or emblem usage considerations. All other legal considerations are the responsibility of the author and his/her/their employer(s).

DTIC Availability Notice

Qualified requestors may obtain copies of this report from the Defense Technical Information Center, Attn: DTIC-OCC, 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, Virginia 22060-6218.

Disposition Instructions

Destroy this report when no longer needed. Do not return it to the originator.

INLINE MONITORING OF FREE WATER AND PARTICULATE CONTAMINATION OF JET A FUEL

INTERIM REPORT
TFLRF No. 466

by
Keri M. Petersen

U.S. Army TARDEC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

for
Joel A. Schmitigal
U.S. Army TARDEC
Force Projection Technologies
Warren, Michigan

Contract No. W56HZV-09-C-0100 (WD27)
SwRI® Project No. 08.19648

UNCLASSIFIED: Distribution Statement A. Approved for public release

April 2015

Approved by:

Gary B. Bessee, Director
U.S. Army TARDEC Fuels and Lubricants Research Facility (SwRI®)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
10-04-2015	Interim Report	September 2013 – April 2015

4. TITLE AND SUBTITLE
Inline Monitoring of Free Water and Particulate Contamination of Jet A Fuel

5a. CONTRACT NUMBER
W56HZV-09-C-0100

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Petersen, Keri M.

5d. PROJECT NUMBER
SwRI 08.19648

5e. TASK NUMBER
WD 27

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army TARDEC Fuels and Lubricants Research Facility (SwRI®)
Southwest Research Institute®
P.O. Drawer 28510
San Antonio, TX 78228-0510

8. PERFORMING ORGANIZATION REPORT NUMBER
TFLRF No. 466

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army RDECOM
U.S. Army TARDEC
Force Projection Technologies
Warren, MI 48397-5000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
UNCLASSIFIED: Dist A
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The U.S. Army is actively pursuing advanced technologies that can monitor aviation fuel cleanliness by detecting and quantifying water and particulate matter. There are several viable options but the preference is to have sensors that are in-line and can perform measurements in near real-time. Although present day particle counting technology may be sufficient for measuring solid contaminants in real time, they can not sufficiently differentiate water droplets or entrained air. The objective of this effort was to conduct an operational test of two developmental, in-line fuel sensors under real-world flow conditions. The sensors were subjected to a range of water and particulate contamination and the results were compared to standard laboratory/field methods.

15. SUBJECT TERMS
Particle counting, sensor, fuel, water, particulate

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			19b. TELEPHONE NUMBER *(include area code)*
Unclassified	Unclassified	Unclassified	Unclassified	11	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

EXECUTIVE SUMMARY

The U.S. Army is actively pursuing advanced technologies that can monitor aviation fuel cleanliness by detecting and quantifying water and particulate matter. There are several viable options but the preference is to have sensors that are in-line and can perform measurements in near real-time. Although present-day particle counting technology may be sufficient for measuring solid contaminants in real-time, they cannot sufficiently differentiate between water droplets and solids. The objective of this effort was to conduct an operational test of two developmental, in-line fuel sensors under real-world flow conditions. The sensors were subjected to a range of water and particulate contamination and the results were compared to standard laboratory/field methods. The testing yielded some promising results but further research will be needed to move the technology forward.

FOREWORD/ACKNOWLEDGMENTS

The U.S. Army TARDEC Fuel and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, performed this work during the period of September 2013 through April 2015 under Contract No. W56HZV-09-C-0100. The U.S. Army Tank Automotive RD&E Center, Force Projection Technologies, Warren, Michigan administered the project. Mr. Eric Sattler (RDTA-SIE-ES-FPT) served as the TARDEC contracting officer's technical representative. Joel Schmitigal of TARDEC served as project technical monitor.

The authors would like to acknowledge the contribution of the TFLRF technical support staff along with the administrative and report-processing support provided by the TFLRF administrative staff.

TABLE OF CONTENTS

Section **Page**

ACRONYMS AND ABBREVIATIONS

GPM	gallons per minute
L/m	liter per minute
mg/L	milligrams per liter
ppm	parts per million
RIO	red iron oxide
SwRI	Southwest Research Institute
TARDEC	Tank Automotive Research Development and Engineering Center

1.0 OBJECTIVE AND BACKGROUND

The objective of this effort was to conduct an operational test of in-line fuel sensors provided by the government. The sensors were designed to detect, differentiate, and quantify free water (0-30 ppm) and sediment (0-5 mg/L) independently. The testing included a comparative analysis of the sensors to standard test methods for water content and particulates.

2.0 TESTING PROCEDURE

2.1 TEST SENSORS

Two sensor systems, from the following companies, were selected by TARDEC for testing in the Southwest Research Institute aviation filtration test facility:

- Progeny Systems Corporation
- J.M. Canty Inc.

2.2 TEST CONDITIONS

Both sets of testing were witnessed by Joel Schmitigal (TARDEC) and a representative from the respective instrument company. Both sensors were installed in-line and subjected to the following nominal conditions:

- System Flow Rate: 105.7 gpm (400 L/m)
- Neat Jet A Baseline
- A-1 Test Dust at 1.0, 0.5 and 0.25 mg/L
- A-2 Test Dust at 1.0, 0.5 and 0.25 mg/L
- A-3 Test Dust at 1.0, 0.5 and 0.25 mg/L
- Water Challenges at 5, 10, 20, and 40 ppm
- Red Iron Oxide (RIO) at 1.0, 0.5 and 0.25 mg/L
- Lowest water detected with RIO
- Lowest water detected with A-1 Test Dust at 0.25mg/L

2.3 TEST MEASUREMENTS

The following measurements were taken during each test:

- gravimetric samples at 5 and 20 minutes per ASTM D2276
- Aqua-Glo to measure free water per ASTM D3240
- particle counts by:
    - Parker ACM 20
    - Parker IOS
    - Stanhope-Seta AvCount
- fuel flow rate
- differential pressure
- fuel temperature
- voltage response of in-line optical sensors.

3.0 RESULTS OF TESTING

3.1 PROGENY

Joel Schmitigal (TARDEC) and Mike Strong and David Beers (Progeny Systems Corporation) visited SwRI the week of 04 November 2013 to witness testing of the Progeny instrumentation. The Progeny instrumentation was installed in-line and the following tests were performed:

- Neat Jet A Baseline followed by A-1 Test Dust at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline followed by A-2 Test Dust at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline followed by A-3 Test Dust at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline followed by water challenge at 5, 10, 20, 40 ppm
- Neat Jet A Baseline followed by Red Iron Oxide (RIO) at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline, Baseline of A-2 Test Dust at 0.25 mg/L, followed by water challenge at 5, 10, 20 ppm

All data was collected and tabulated and, per TARDEC's request, submitted independently of the final report. A detailed report was to be prepared by TARDEC.

3.2 CANTY

Joel Schmitigal (TARDEC) and Justin Halbach (J.M. Canty Inc.) visited SwRI the week of 03 November 2014 to witness testing of the Canty instrumentation. The Canty instrumentation was installed in-line and completed the following tests:

- Neat Jet A Baseline followed by A-1 Test Dust at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline followed by A-2 Test Dust at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline followed by A-3 Test Dust at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline followed by water challenge at 5, 10, 20, 40 ppm
- Neat Jet A Baseline followed by Red Iron Oxide (RIO) at 1.0, 0.5, 0.25 mg/L
- Neat Jet A Baseline, Baseline of A-2 Test Dust at 0.25 mg/L, followed by water challenge at 5 ppm

All data was collected and tabulated and, per TARDEC's request, submitted independently of the final report. A detailed report was to be prepared by TARDEC.

Overall, the Canty instrumentation was unable to operate under higher flow rates. The flow rate was limited to 29 GPM, but the desired flow rate was 105.7 GPM. There were several cases where a particle was classified as both a water droplet and dirt particulate. The sample size was also very small compared to standard particle counters. The Canty instrument was, however, able to detect and distinguish between water and dirt passing by the lens.

4.0 CONCLUSION

Overall, both systems showed positive results. However, each system would require additional research and development to enhance its ability to differentiate between dirt particles and water droplets. The fuel sample size needs to be more comparable to that of the standard particle counters and results will likely need to be presented in ISO 4406 codes in order to be accepted by the industry. A more extensive discussion about each sensor will be provided in the forthcoming reports from TARDEC.